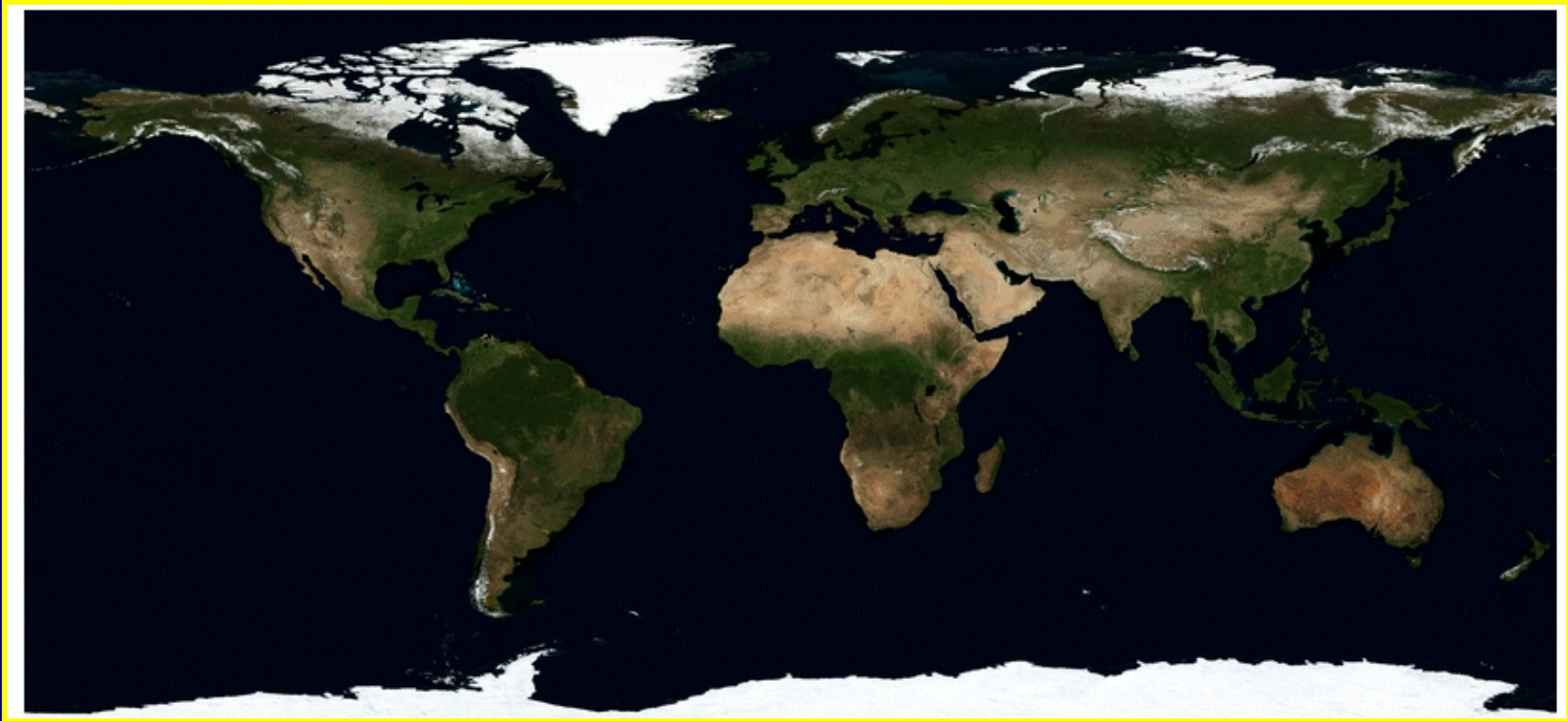# Global Agriculture Land Cover:
Data, Analysis, & Dissemination
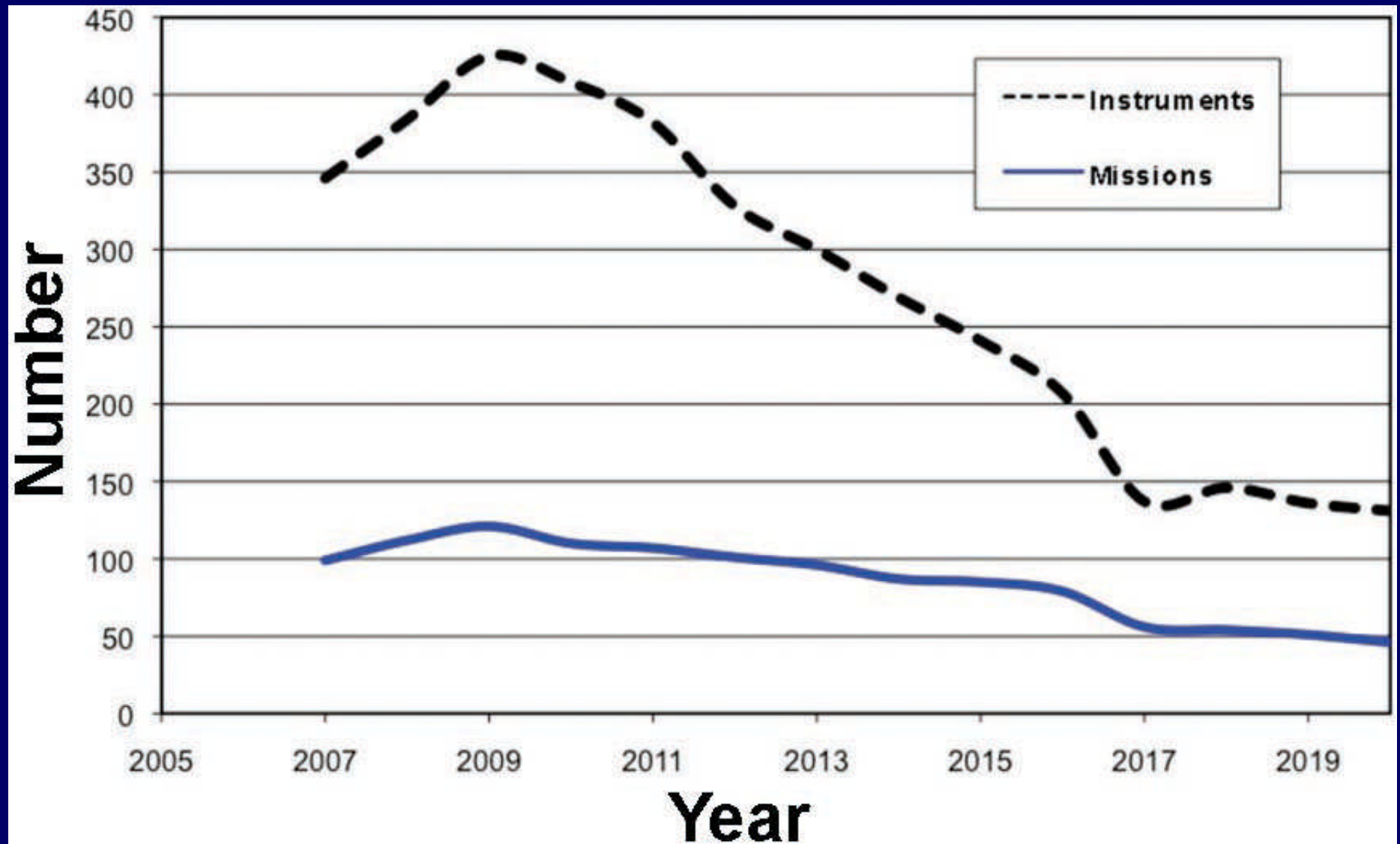

Compton Tucker

NASA/GSFC & CCSP

April 22, 2009

Global Agricultural Land Cover -- Satellites are crucial for global data

- **Land Photosynthesis – time series**
  - AVHRR-MODIS-<u>VIIRS</u>
- **Land Use/Land Cover Change –**
  - Landsat, AWiFS, & AVHRR-MODIS
- **Vegetation height and structure**
  - DESDynI's InSAR & Lidar
- **Quickbird/Rapid Eye**
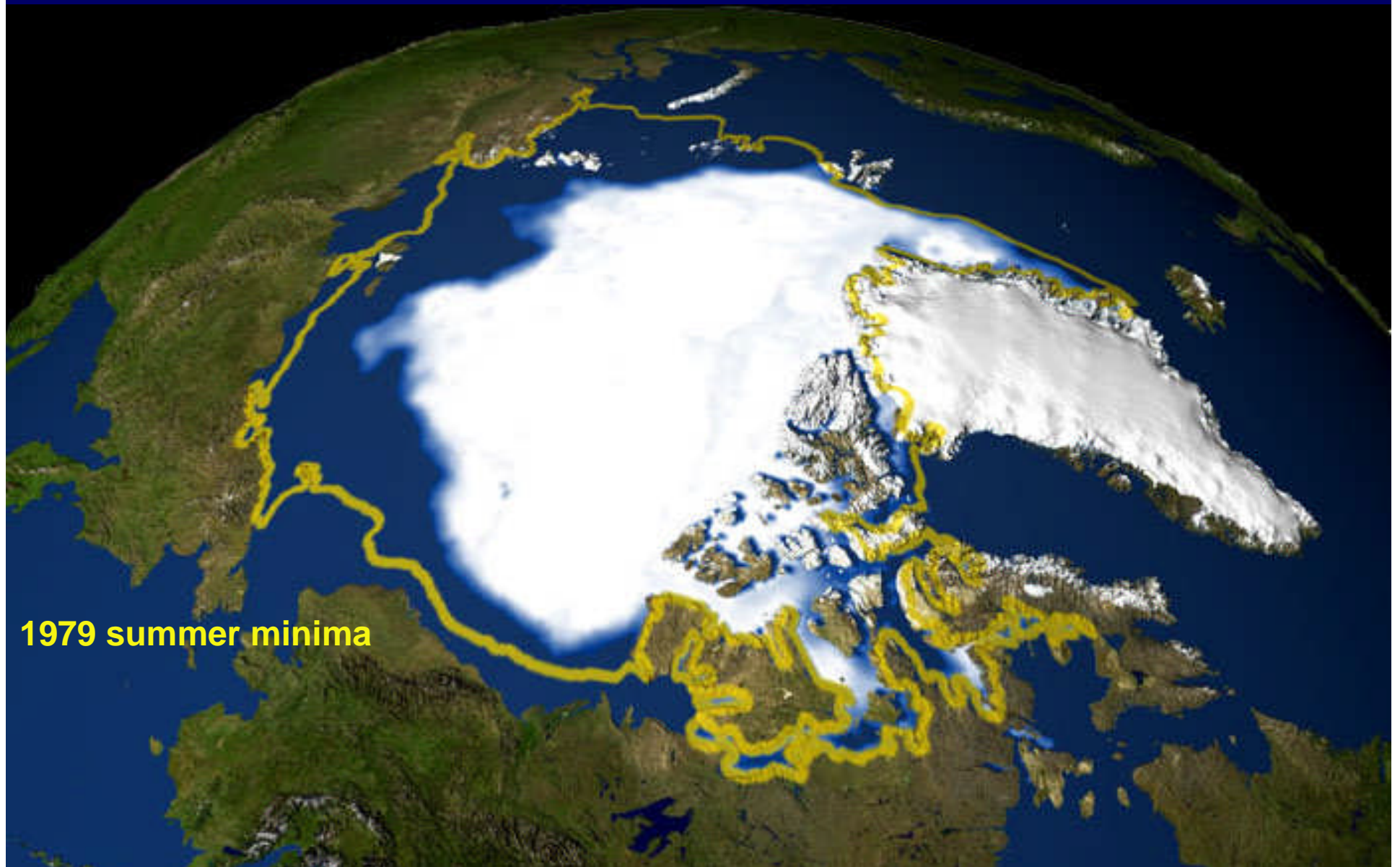 - Hyper spatial data

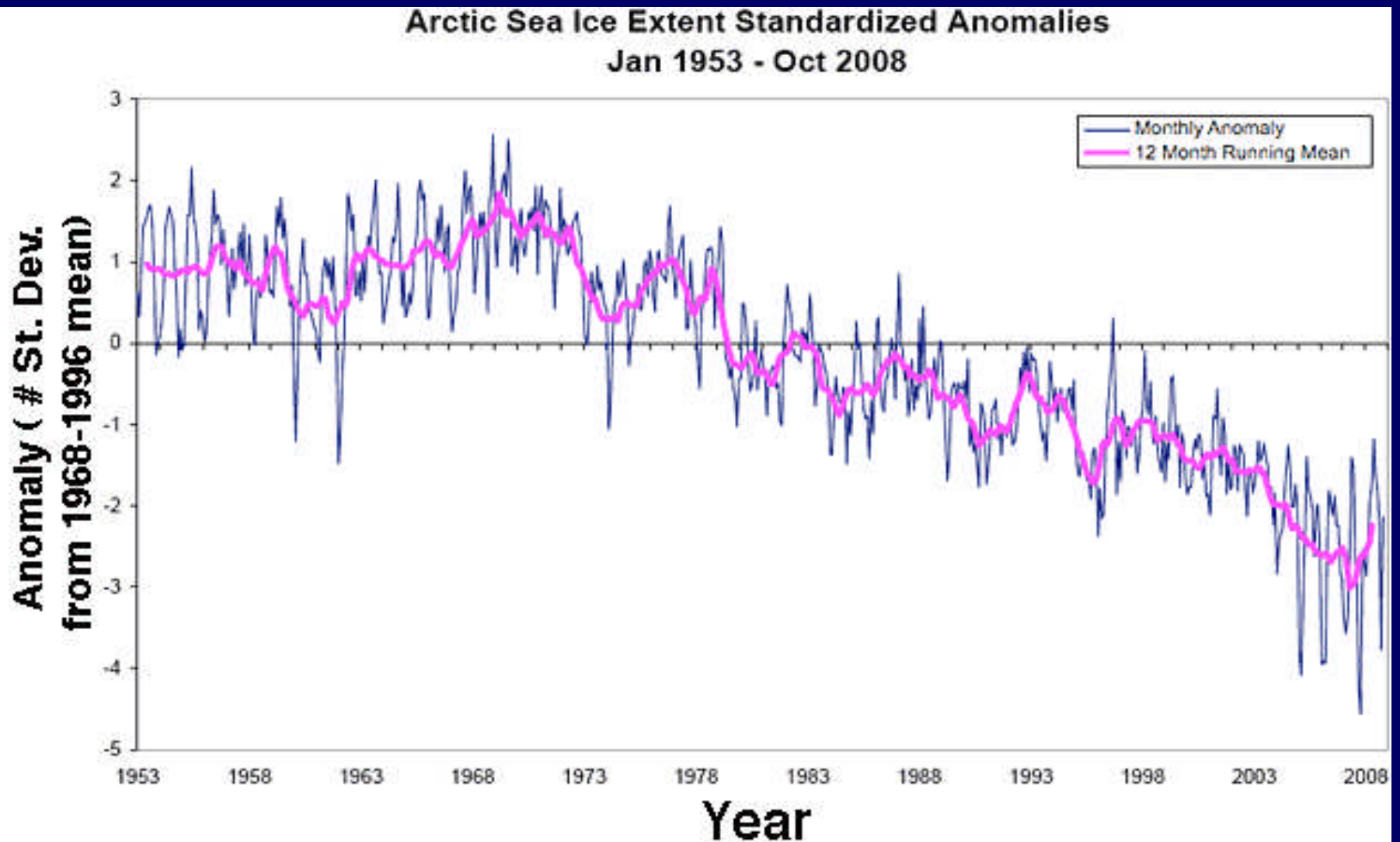# Status of Civilian Space Assets

Houston, We Have a Problem...

We are altering our planet's climate

Arctic Sea Ice Trends
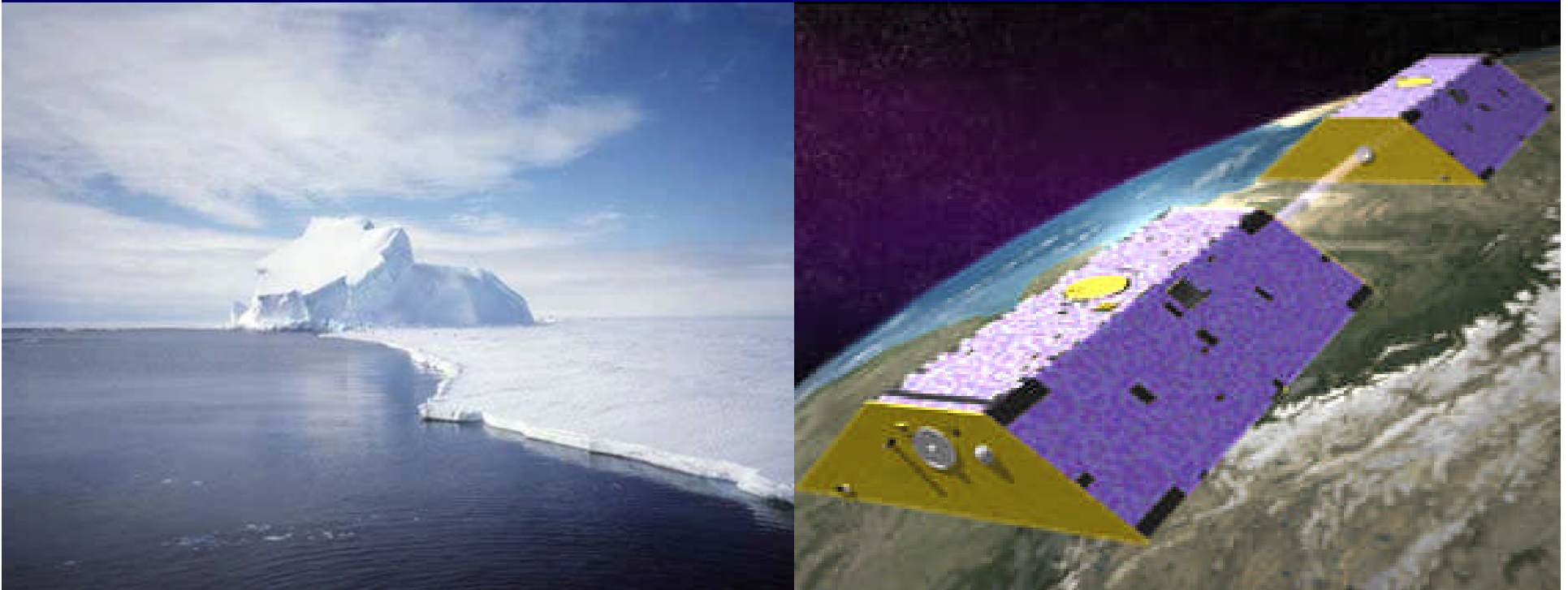

1979 summer minima

Arctic Sea Ice Trends

Arctic Sea Ice Extent Standardized Anomalies
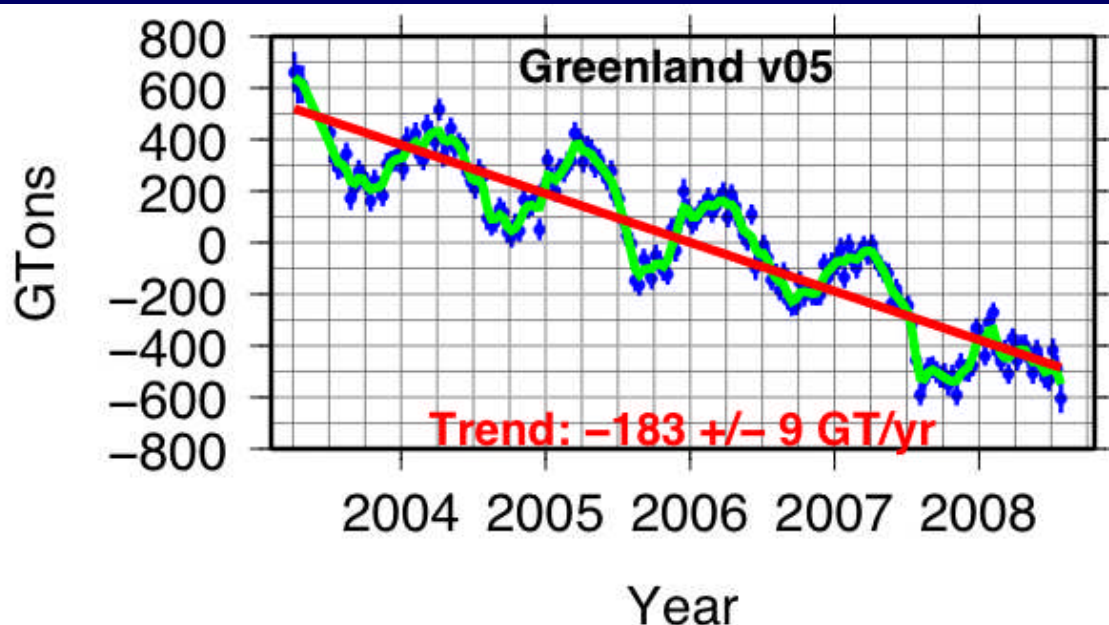Jan 1953 - Oct 2008

Seasonal and Interannual Evolution of the Earth's Land Ice from GRACE MASCON Solutions

S. B. Luthcke, D.D. Rowlands, J.J. McCarthy, A.A. Arendt, H.J. Zwally, W. Abdalati, D.K. Hall, J.P. Boy, F.G. Lemoine

*AGU Fall Meeting Dec. 19, 2008, San Francisco, CAC43A-05*

Greenland Mass Balance from GRACE Mascon Solution

NASA GSFC mascon solution

Update to:

Luthcke, S.B., H.J. Zwally, W. Abdalati, D.D. Rowlands, R.D. Ray, R.S. Nerem, F.G. Lemoine, J.J. McCarthy and D.S. Chinn, "Recent Greenland Ice Mass Loss by Drainage System from Satellite Gravity Observations," *Science* 314, 1286 (2006) (10.1126/science.1130776).
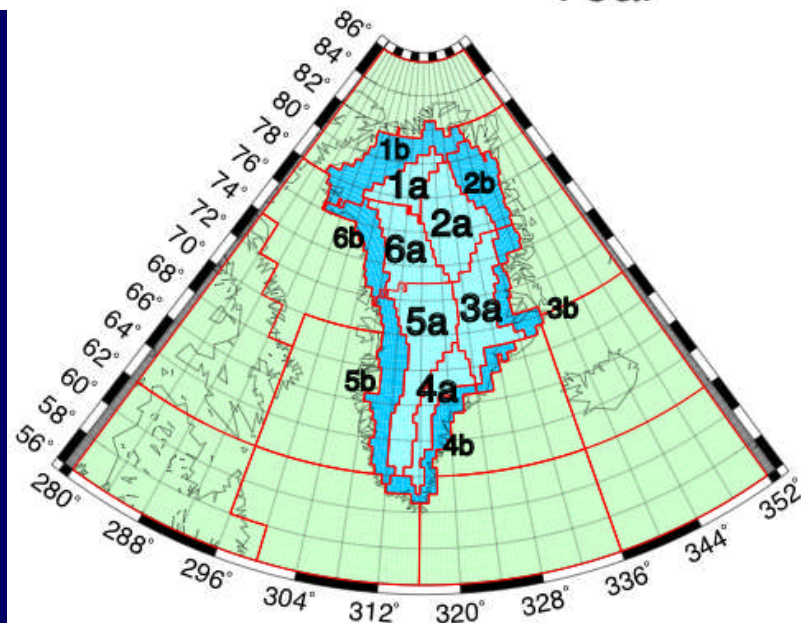
Time Period	Trend Gt/yr
Jul03 - Jul05	-105 ± 11
Jul03 - Jul06	-136 ± 8
Jul03 - Jul07	-150 ± 6
Jul03 - Jul08	-183 ± 9

"Ladies and Gentlemen, it's time we gave some serious thought to the effects of global warming"

Key climate & Ag. sensors

Absolutely crucial climate/Ag. sensors:

- **Landsat 1972 – now**

- **AVHRR-MODIS-VIIRS 1981 -- now**

- **Lidar & InSAR for the 3rd Dimension (DESDnyl)**

Why?

Land use, land cover change/climate

Carbon cycle land/climate
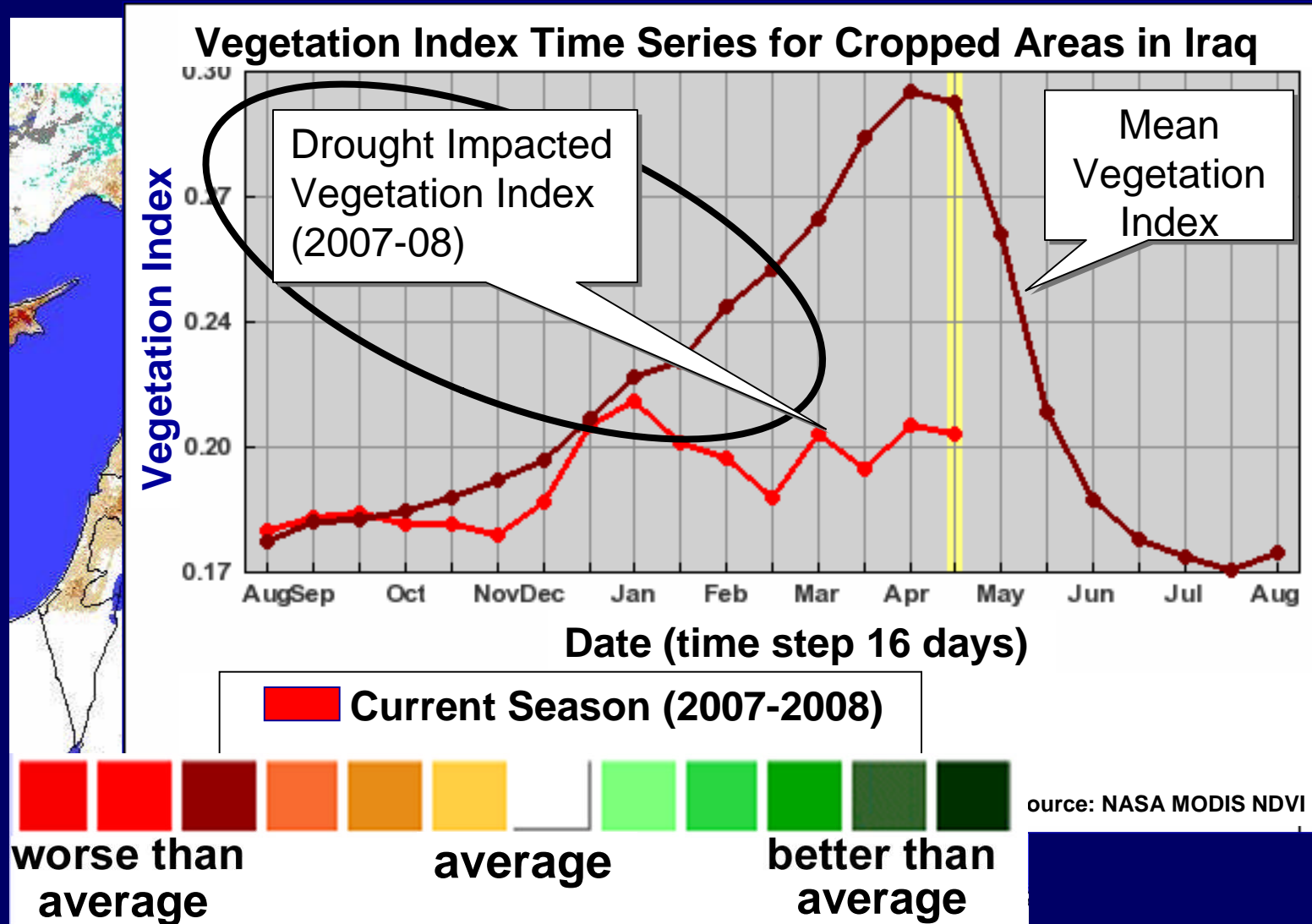
Global Agriculture monitoring

Landsat – A key climate & Agricultural land cover sensor?

1. 30 m spatial resolution close-to-perfect match to surface variability (Townshend and Justice 1988)

2. Spectral bands are well situated

3. Repeat cycle OK

4. Excellent data system

How to enhance Landsat

- Landsat exploits the spatial & spectral domains
  - 30 m spatial resolution excellent
  - Excellent spectral band selection
- **Exploit the time domain (e.g. AVHRR, MODIS, Seawifs, etc.) but at 30 m spatial resolution with TM/ETM spectral bands**
- **Wider field of view, 4-5 day repeat cycle**
- **Build multiple instruments (e.g. Landsat-5's TM) = Continuity!!**

Tracking the 2007-08 Iraq Drought through the GLAM MODIS Web-Interface NDVI Anomalies

Vegetation Index Time Series for Cropped Areas in Iraq

Drought Impacted Vegetation Index (2007-08)

Mean Vegetation Index

Date (time step 16 days)

Current Season (2007-2008)

worse than average

average

better than average

Source: NASA MODIS NDVI

Ecosystem changes can be seen in vertical height & density distributions of vegetation & in spatial heterogeneity

Disturbance event

Carbon Sink

Height

Forest opening

Young Regrowth

Older Regrowth

Mature Forest

Time
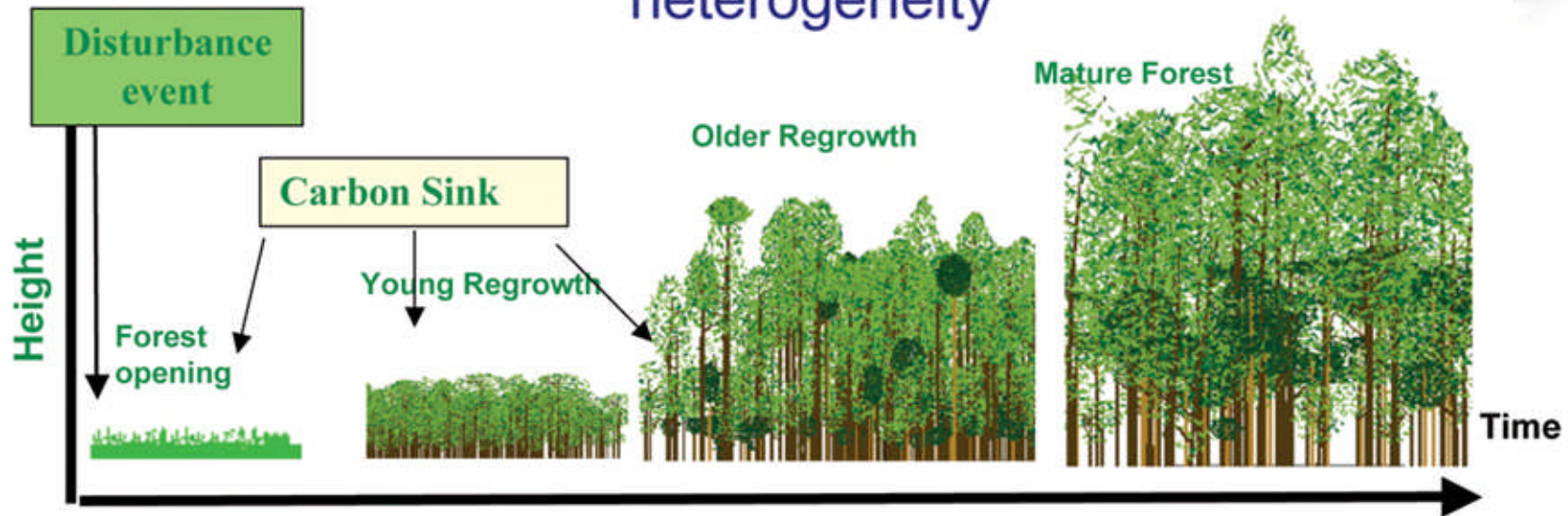
More Biomass

(figure from J. Drake)

Disturbances from fire, logging, insects, disease, storms

Disturbances are major forces that determine transition of forest stands, landscapes, and regions to & from carbon sinks to sources .
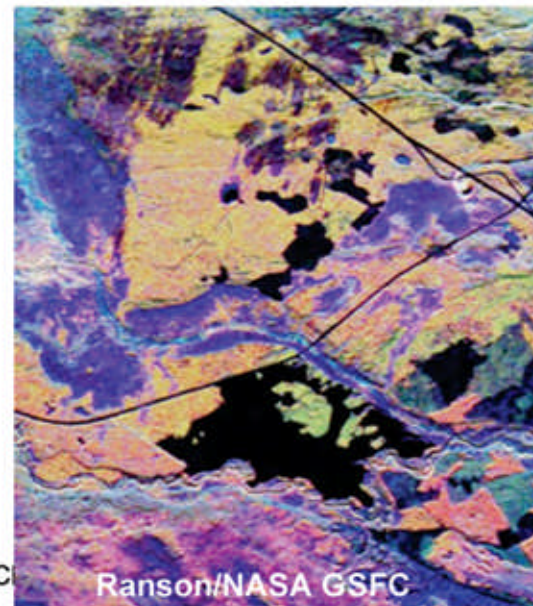
Forests tend to be patchy due to natural and human disturbances.

Radar image from Canada shows evidence of fires (dark areas at top) and logging (e.g.,black features in center)

Ranson/NASA GSFC

jba - 43

MODIS Rapid Response Interface with FAS Crop Explorer

Monitoring Floods in the Zambezi River with MODIS Rapid Response

MODIS RR Image March 25, 2009
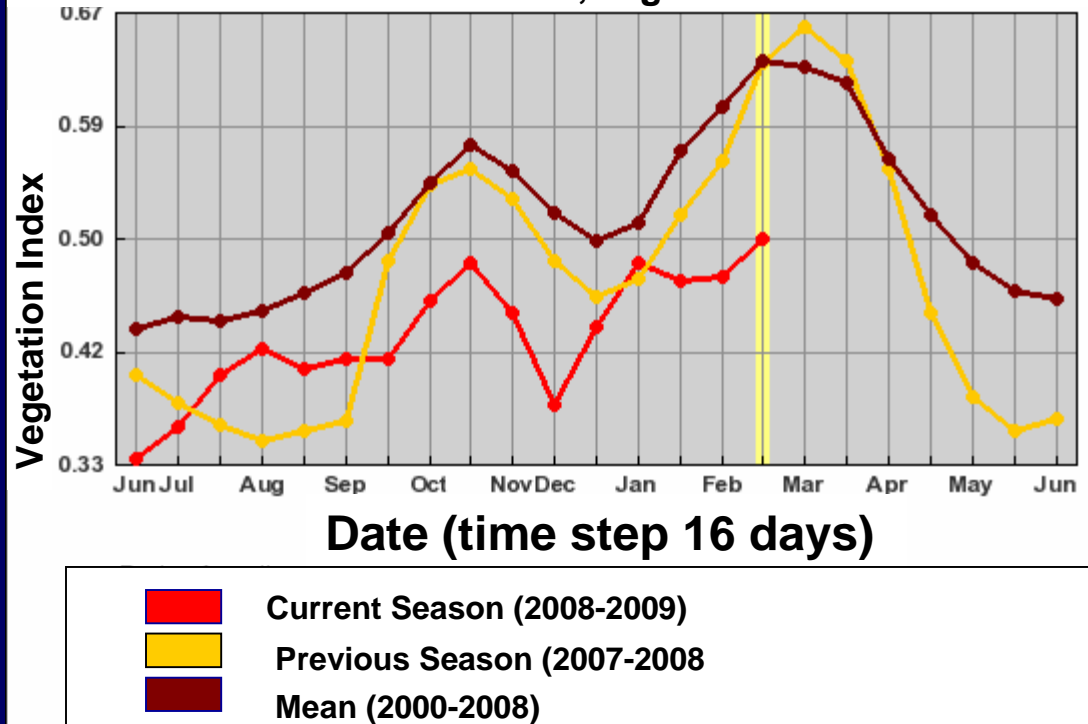
MODIS RR Image January 4, 2009
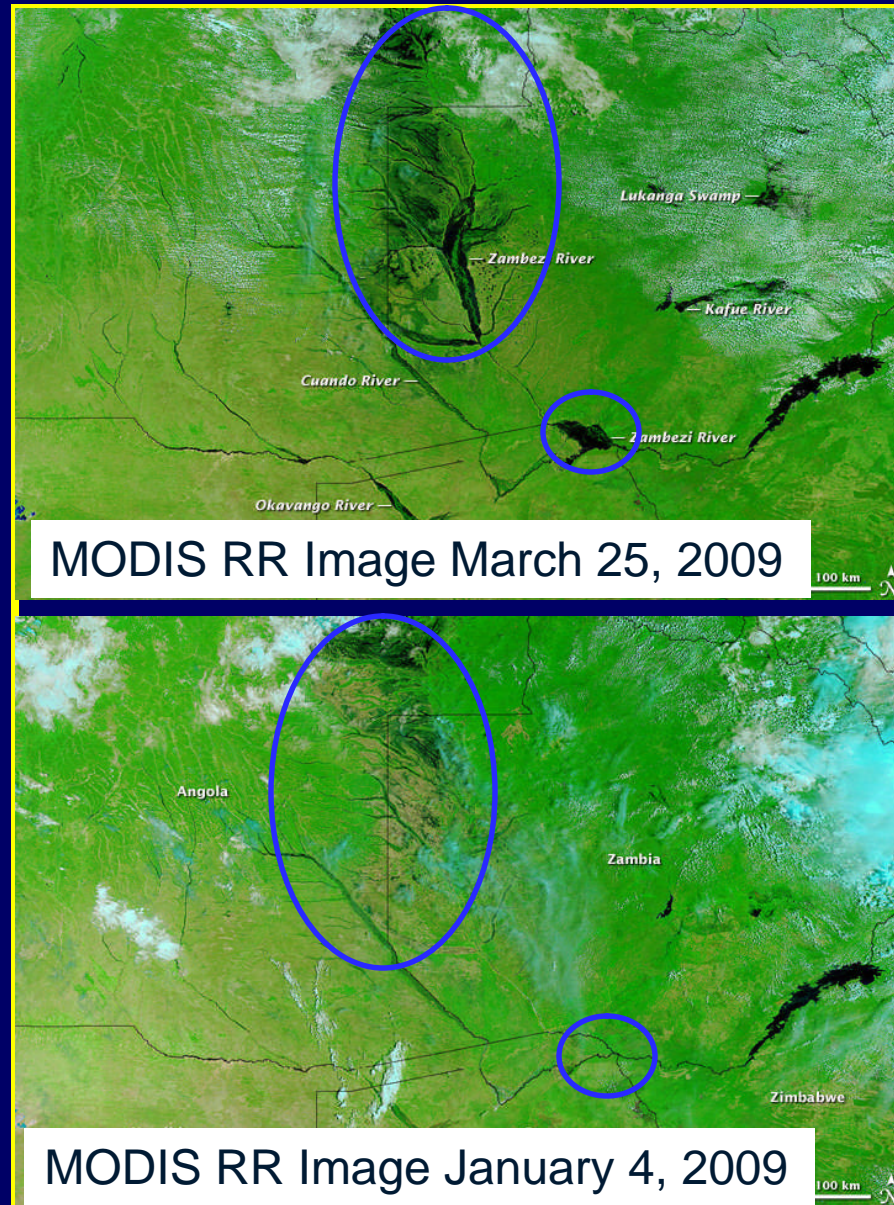
Example of Utility of the GLAM MODIS NDVI DBMS to Track Current Drought Impact on Crops in Argentina

Buenos Aires NDVI Anomaly Image
Feb 02-Feb 17, 2009
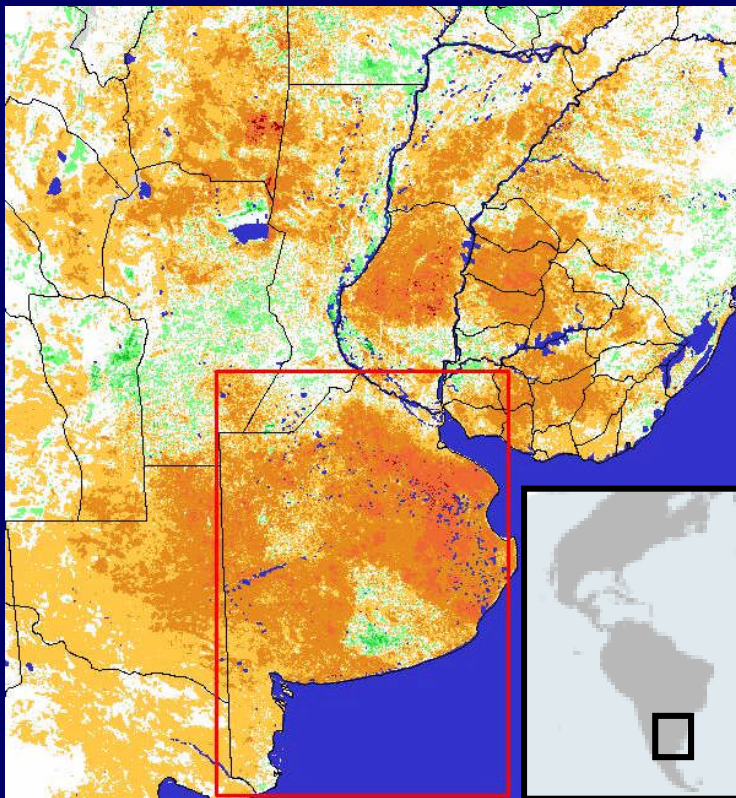
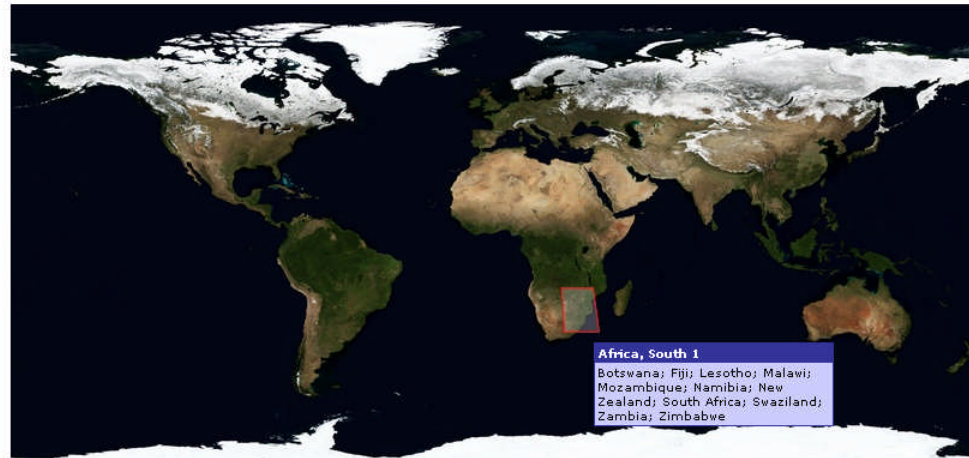**Vegetation Index Time Series for Cropped Areas in Buenos Aires, Argentina**

Date (time step 16 days)

- Current Season (2008-2009)
- Previous Season (2007-2008
- Mean (2000-2008)

GLAM Web Based MODIS DBMS Component
250-m VI/MODIS time-series from 2000-present

- A global NDVI time-series database is produced at a spatial resolution of 250 meters with a 16-day compositing period

- - Current system data delivery lag is between 3-14 days after last day of composite

250-meter MODIS/NDVI Time Series Database from the Global Agriculture Monitoring (GLAM) Project

Please select your region of interest by clicking on the globe ❷ or selecting from the list

Africa, South 1
Botswana; Fiji; Lesotho; Malawi; Mozambique; Namibia; New Zealand; South Africa; Swaziland; Zambia; Zimbabwe

Select Region (None - Return To Front Page) ❷

First Dataset from New FAS GLAM NRT System!

Latest MODIS NDVI standard product available is the Feb 18- March 5th composite

NDVI Image for March 6-21 2008
Available since Monday 23rd
Several days prior to the standard MODIS NDVI product!
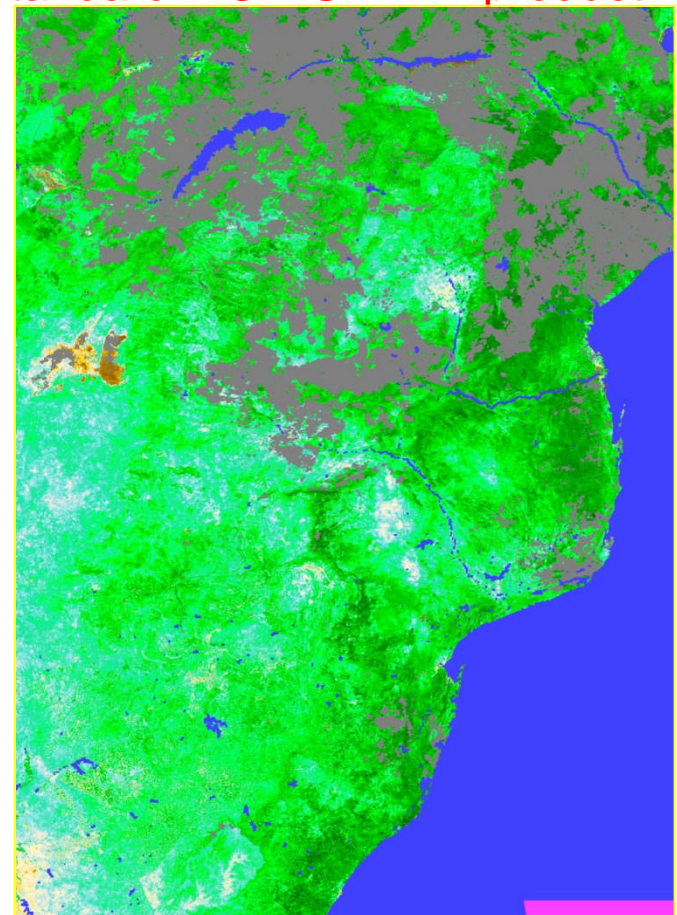
Collaborators

- **NASA/GSFC**
  - Compton Tucker, Assaf Anyamba, Ed Masouka, Jen Small, Ed Pak, Jeff Schmaltz
- **University of Maryland Department of Geography**
  - Chris Justice, Mark Sullivan, Eric Vermote
- **South Dakota State University**
  - Matthew Hansen, Kyle Pittman
- **USDA Foreign Agriculture Service (FAS)**
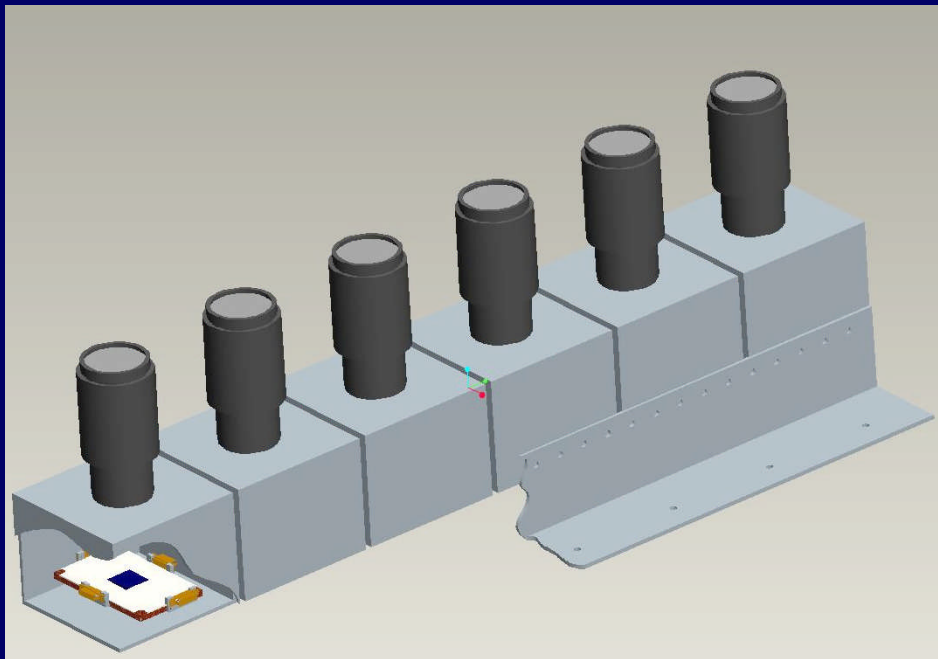 - Brad Doorn, Curt Reynolds

TD30m Venture Class Instrument
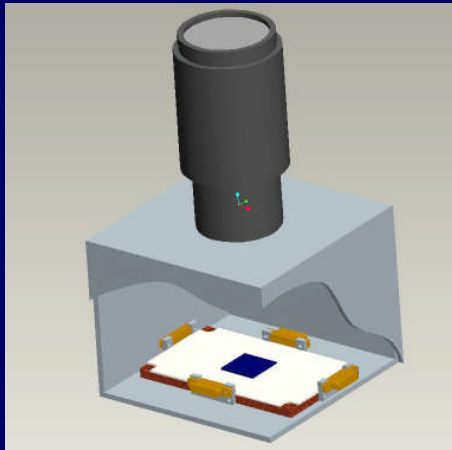
Single Camera Module
One 640 x 512 InGaAs Det. Array
5 beam slices per module
Swath = 96 km
GSF= 30 m
Spectral band = 0.4 - 1.7 μm
Several modules for operation
~3% module overlap
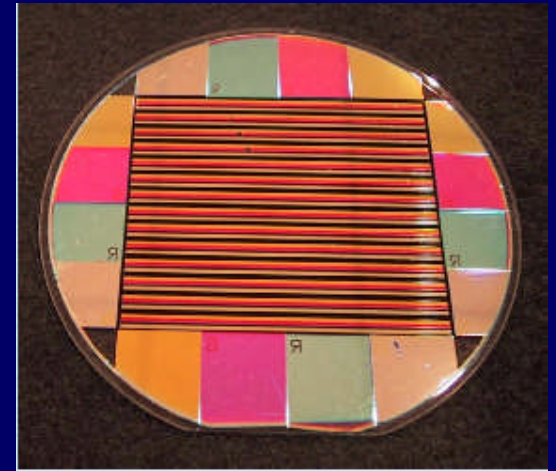
Multi-band Filters from
Barr unpackaged

Data Rate per Camera Module:
Assuming 700 nm sun sync. Orbit,
Velocity of S/C = 7000 m/sec.
Using 30 m ground resolution would
Require 6.7 μsecond pixel readout
Well within the 190 frames/sec.
detector speed

TD30m Venture Class Costing

- Each camera module would be ~ $3M, Total for 6 modules = <$20M

- The Camera Electronics Box (CEB) ~ $10M

- Alignment, Integration & Test ~ $3M

- Calibration ~ $2M

- Data Compression ~$6M

- Total Instrument: ~$40M
- Major in-house project
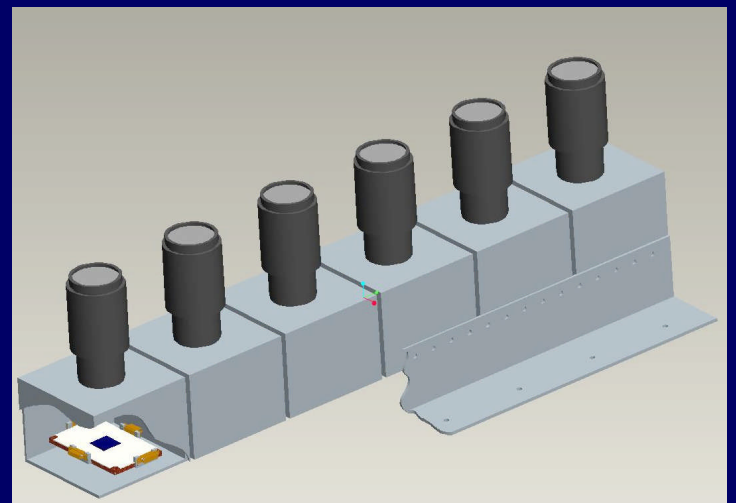
GLAM System Web Interface for Querying and Analyzing MODIS VI Time Series

GLAM System Data Delivery Lags 2007-2008 Versus New FAS System Lags (in number of days after last compositing day)
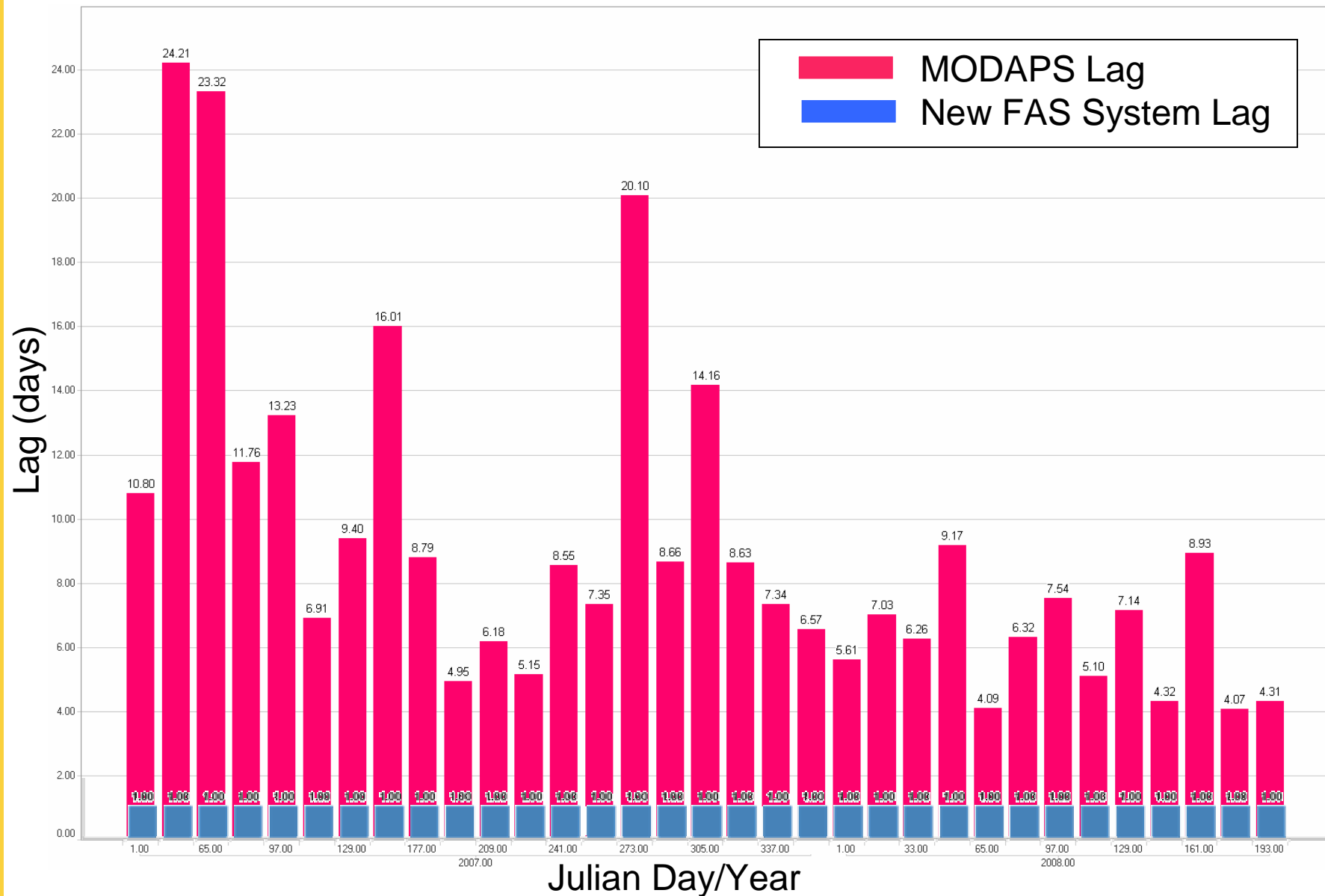
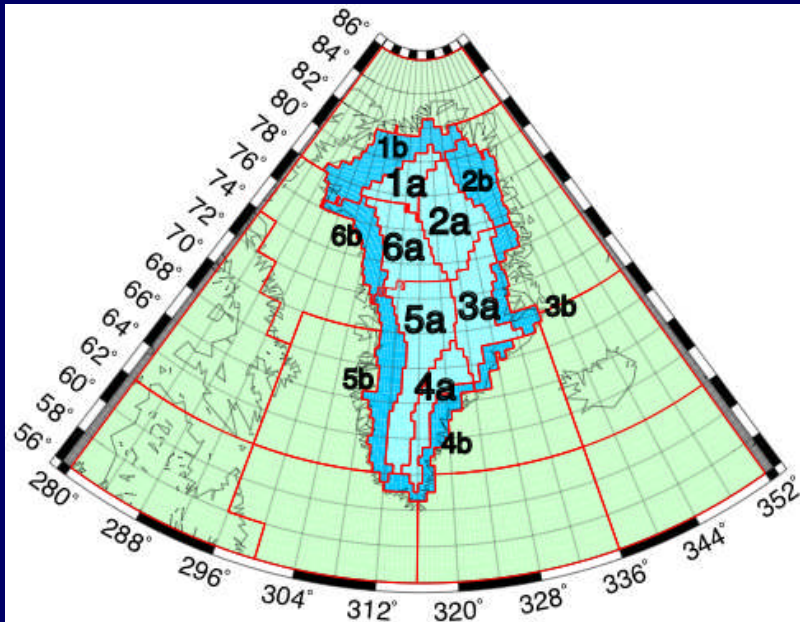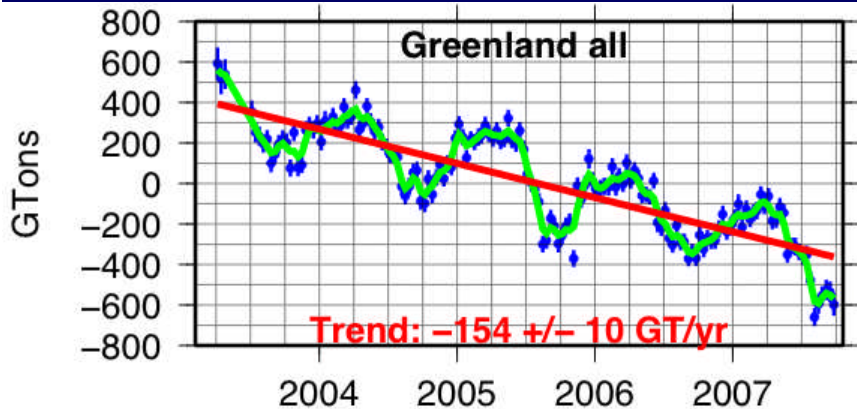# Gravity Recovery & Climate Experiment

500 km orbit

220 km separation

Distance accuracy ± 0.001 mm

Greenland Ice Mass Flux from GRACE mascon solution

NASA GSFC mascon solution (update to Luthcke et al. Science 2006)

Losing 154 Gt of ice per year ! (update to Luthcke et al. Science 2006)

154 Giga-ton = 154,000,000,000 metric tons

1 metric ton = 2,205 lbs.

154 Giga-ton ~ 168 km³ of ice or 40.3 mi³ of ice

Nearly 2.5 times the amount of water in the Chesapeake bay !

Nearly 10 times the average annual flow of the Colorado river !

0.43 mm/yr to global sea level rise.

Photo Credit: Roger Braithwaite